Account of a mass aggregation of Port Jackson sharks *Heterodontus portusjacksoni* at Point Cooke Marine Sanctuary, Victoria, Australia

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Abstract
In January 2009, a mass aggregation of over 100 Port Jackson sharks *Heterodontus portusjacksoni* was noticed during a recreational snorkel at the Point Cooke Marine Sanctuary. The sharks (which all appeared to be female) were observed over two consecutive days in January 2009, after which they evidently departed en masse. The habitat being used at Point Cooke Marine Sanctuary appeared to be different from that typically used by this species (which from literature sources appears to include caves and rock ledges that allow sharks to be 'tucked away' and difficult to access). The reasons for the aggregation are unknown, but no sharks were observed to be actively foraging at the time of the aggregation, nor participating in any mating or egg-laying behaviour, suggesting that a male avoidance strategy may have been implemented by these animals. (*The Victorian Naturalist* **132** (4), 2015, 108–117)

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Introduction

A mass aggregation of over 100 Port Jackson sharks (*Heterodontus portusjacksoni*) was noticed during a recreational snorkel at the Point Cooke Marine Sanctuary over two consecutive days in January 2009. This account aims to describe what appears to be a relatively very unusual occurrence, since in the literature there are virtually no recorded or documented instances of mass aggregations of this size and type.

Dates of sightings

The sharks were first observed at approximately 11:00 on Sunday, 4 January 2009 during a routine recreational snorkel. The sharks were still present during another snorkel at around 2.00 pm on the same day, and were also found at approximately 1:00 pm on Monday, 5 January 2009, but all had left the area by approximately 10.00 am on Tuesday, 6 January 2009. To summarise, four recreational free dives were conducted, and the sharks were present during three of them. It is unknown how long these sharks had actually remained in this location prior to the initial sighting on 4 January, and all observations described herein were conducted opportunistically and were not part of a defined sampling program.

Location and habitat of shark aggregation

The approximate location of this sighting at the Point Cooke Marine Sanctuary was 37°55'24.52"S and 144°47'58.62"E (Fig. 1).

The aggregation occurred off the south-eastern side of the shore near emergency location area PCC506, near the Point Cooke Homestead, placing it within Altona Bay (Fig. 2). The area was between 50 and 80 metres offshore, past a number of rocks in the shallow intertidal zone that exhibit heavy coverage of the calcareous tubeworm *Galeolaria caespitosa*, and also features an intertidal seagrass meadow.

Access to this site was easily made by walking to the eastern side, thus avoiding trampling the seagrass beds as well as the boulders, which are festooned with sea urchins and thus present a potential injury risk to waders.

The majority of sharks were found in water of 1.5 and 2 metres depth, depending on bottom topography. The benthos in this area consists of basalt reef and boulders, interspersed with sand patches and extensive colonisation by the green algae *Ulva* spp. (Fig. 3).

No ontogenetic (age) differences in habitat use were noted on this occasion, with the distribution of sharks according to size appearing to be random.

The section of the Point Cooke Marine Sanctuary that the sharks were residing in during their mass aggregation does not feature dense coverings of macroalgae; the dominant algal species in the area tend to be the southern sea

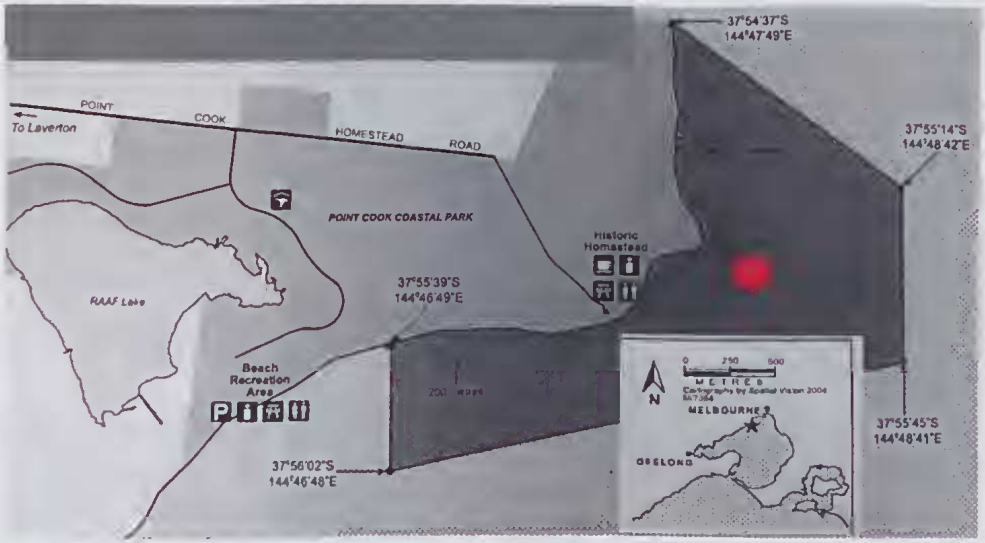

Fig. 1. Approximate location of the shark aggregation, as indicated by a red circle. Location of the suburb of Point Cook is demonstrated by the position of the star on the map inset (Photo: modified from Parks Victoria, 2004).

Fig. 2. View from PCC506 at low tide from the shore. The emergency location sign appears at the right, with a sign on the left indicating that the location is Point Cook. The aggregation of sharks appeared to the left side (to the south-east) of the intertidal area.

(a)

(b)

Fig. 3. The location where the sharks were sighted, as viewed from under the water, (a) with boulders and rocky bottom; and (b) with intermittent sand patches.

lettuce *Ulva rigida* and/or *U. australis*, and *Sargassum* spp. is also common, while at the time of the sighting, the invasive marine pest species *Undaria pinnatifida* (Japanese kelp or Wakame) was in a state of dieback. As it stood, none of these macroalgal species would have provided appreciable levels of shelter. This, combined with the shallowness of the water, meant that all animals were very exposed to the solar radiation that was present at the time.

Very high solar radiation readings were recorded on both days (34.8 and 34 MJ/m^2 on Sunday and Monday respectively) (Data: Bureau of Meteorology) that the sharks were sighted, due to the time of year (summer), the consequently long photoperiod, and the minimal cloud cover that was present during the times the observations were made.

Prevailing conditions

Bureau of Meteorology data from the nearby Laverton RAAF base for the days that the

Table 1: Daily maximum and minimum temperatures and rainfall totals for the period around the sighting of the shark aggregation (Source: Bureau of Meteorology).

Date	Day	Maximum air temperature (°C)	Minimum air temperature (°C)	Rainfall (mm)
3 January 2009	Saturday	19.2	6.5	0
4 January 2009	Sunday	24.7	7.2	0
5 January 2009	Monday	25.6	9.4	0
6 January 2009	Tuesday	29.8	12.4	0

sharks were observed to be *in situ* and a day either side of the aggregation being noted is shown in Table 1.

The wind during all days in which observations were conducted was relatively light, with seas being calm and wave heights generally below 0.5 m. Tidal heights varied between a low of 27 cm to a high of 88 cm while the sharks were present at the aggregation site.

The contention from several authors (including Last and Stevens, 1994) that the species generally returns to rocky gullies and caves during the day appeared to be flouted on the days in question by the animals in this aggregation, as the sharks stayed in the same area for at least 48 hours during day time and presumably also at night time, given the sheer size of the aggregation.

On 3 January illuminaytion from the moon was 37.7% of that from a full moon, increasing to 48.4% and then 59.5% on the two days that the aggregation was observed. This increased further to 70.5% (Timeanddate.com website, http://www.timeanddate.com/moon/australia/melbourne) on the day the sharks were no longer observed in the area. Sunday 4 January marked the start of the first quarter lunar phase, with a full moon appearing on 11 January, well after the sharks had left the area (Data: Planetarium, Museum Victoria website, http://museumvictoria.com.au/planetarium/discoverycentre/moon-phases/)

Shark numbers

The school of sharks in this case was estimated to number well in excess of 100 individuals, an estimate that was made easier based on their generally docile and stationary disposition, and the relatively small area that they were found to inhabit. One area that was observed to be barely 5 m × 5 m or 25 m^2 contained 27 sharks, with many stacked one on top of the other. The total area that the sharks occupied was difficult to estimate because of the patchy distribution of the sharks, though there was not much distance between sharks in adjacent areas. The aggregations on both days seemed to be of similar size.

Shark sex and size

The Port Jackson shark, like all elasmobranchs, features obvious sexual dimorphism in that males and females can be distinguished readily upon examination of their genitalia. Claspers on the males of this species, like those of many elasmobranchs, are prominent (Fig. 4), and none were seen. In this instance, shallow water made lateral observations possible; these are useful for providing additional qualification of the sex of the sharks. Claspers on male animals may be difficult to detect if the shark is stationary and the claspers sit in line with the body and are concealed by the shark's dorsal surface; objects that may be present in the benthos, such as rocks and macroalgae, may also hinder observations. In this case it certainly appeared that all animals observed were in fact female. While the author did not survey every single shark in the mass aggregation, and it is therefore possible that males could have been concealed amongst the school, it is certain that these males would have represented an extreme minority, if they were present at all.

Lengths of the sharks varied between 40 cm and 120 cm, with no specific size segregation apparent.

Shark behaviour

All sharks were observed to be extremely docile, with very few sharks actively swimming; their behavioural pattern can therefore be de-

Fig. 4. The claspers of a male Port Jackson shark (total length approximately 70 cm) photographed at nearby Ricketts Point Marine Sanctuary.

scribed accurately as 'resting'. No foraging was observed to be taking place.

On a couple of occasions some sharks were observed to swim away when approached, but this was to be expected considering the size of the observer (approximately 181 cm tall and 79 kg, and the additional length of the flippers) being considerably larger than any of the observed sharks. Sharks that did relocate generally swam only a very short distance (10 metres or less) before settling again on the benthos. At no stage did the author ever feel threatened hy the sharks, with no aggressive or even investigative approaches instigated. No sudden or erratic movements were made hy the author, and all movements towards sharks were very slow and deliberate, so as not to alarm the animals.

Other occurrences of Port Jackson sharks and other elasmobranchs at Point Cooke Marine Sanctuary

Prior to this occurrence, the author had never seen a Port Jackson shark at the Point Cooke Marine Sanctuary, despite snorkelling sporadically in the area between 1997 and November 2005, when the author moved to the area and then snorkelled regularly, up until the present time. Only a few other Port Jackson sharks have been seen since the mass aggregation, with another sighting of a female made on 24 October 2009. In this incident, the shark appeared to have her head down amongst some rocks and was making twisting motions with her body, which assumed a nearly vertical attitude suspended in the water column. This could have been suggestive of either foraging behaviour or the planting of an egg case, though no evidence of either was found upon examination of the benthos where her head had been. The month of October fits with Stevens' (1987) assertion that this period is when the laying of eggs takes place. Another female (possibly gravid on account of a somewhat distended abdomen) was sighted during September of 2014 (Fig. 5).

In additon to sightings of sharks, the occasional egg case has been found washed up on the beach (Fig. 6), even though these have generally not been in very high numbers, with only a few sighted over the years. This would seem to indicate that Point Cooke Marine Sanctuary is not a very well frequented area, and certainly not a residential haunt, of this particular species.

The low number of sightings of Port Jackson sharks in the shallows of the Point Cooke Marine Sanctuary must he considered a true indication of their general lack of presence in this area, since experienced snorkellers and divers are able to spot similarly sized animals such as stingrays and stingarees even when only the eyes and spiracles (accessory breathing organs)

Fig. 5. A female Port Jackson shark sighted near the location of the mass aggregation several years later in September 2014.

are visible. It appears that Point Cooke Marine Sanctuary is something of an elasmobranch haven, with at least six species of ray having been sighted within the boundaries of the sanctuary, including the Southern Fiddler Ray *Trygonorrhina dumerilii*, which is extremely common during the summer months in particular, and the eastern shovelnose stingaree *Trygonoptera imitata*, and Sparsely Spotted Stingaree *Urolophus paucimaculatus*, which can also be found in considerable numbers in the sanctuary. Also encountered are the Southern Eagle Ray *Myliobatus australis*, the less common Spotted Stingaree *Urolophus gigas* and the Smooth or Short-tailed Stingray *Dasyatis brevicaudata*. Other shark species sighted in the Point Cooke Marine Sanctuary include the Gummy Shark *Mustelus antarcticus*.

Observations of marine life during the summer months are generally limited by the prevailing weather conditions. During hot and sunny days, the norm is for northerly winds to flatten out the surface of Port Philip Bay in this location during the morning hours, thus allowing greater visibility. During the afternoon, however, sea breezes from the south tend to prevail and cause greater wave swash and surge, reducing visibility.

On the occasions of these sightings visibility was found to be between 4 and 6 metres, which is relatively good for the location, with absolute maximum visibilities observed to be around 10 to 12 metres. Unfortunately, the best visibility in this section of Port Philip Bay often occurs during the winter months, when elasmobranchs of any type are relatively rare at Point Cooke Marine Sanctuary; they seem to be very common from October to March, and numbers then start dwindling from April right through until September, when they start to return.

Fig. 6. A Port Jackson shark egg case (110 mm long and 74mm wide), which was found beyond the western boundary of Point Cooke Marine Sanctuary in 2006.

Possible reasons for this mass aggregation

There are myriad reasons why this aggregation may have occurred, and as is often the case with opportunistic observations these are necessarily speculative; however, the aggregation of such a large number of individuals is surely worth recording and discussing further.

Location — why Point Cooke Marine Sanctuary?

Ultimately, we can only speculate on why the Port Jackson sharks that formed this massive school chose Point Cooke Marine Sanctuary

as their aggregation destination. Hutchins and Swainston (1996) noted that this species prefers protected reef and adjacent sand and weed areas, and noted that several may crowd together in one cave. Point Cooke Marine Sanctuary does not feature caves in the shallow subtidal region, but instead features a mixture of seagrass meadows, sand patches, and basalt reefs with boulder fields and urchin barrens. Boulders and the like could be considered as potentially suitable areas for the laying/planting of the spiralled egg cases that are characteristic of the species, since females tend to lay eggs and then plant them in rock fissures with their mouths on inshore reefs in areas less than 5 m deep (Last and Stevens 1994). Since no oviposition behaviour or the presence of eggs were observed, and apparently all sharks were female, and given that the timing of these observations was outside the expected parturition period for this species, egg laying and breeding can be ruled out as reasons for this mass aggregation, as will be discussed in more detail shortly.

The Port Jackson sharks of Ricketts Point Marine Sanctuary

Areas such as the Ricketts Point Marine Sanctuary, near Beaumaris on the north-eastern side of Port Phillip Bay, are renowned haunts for Port Jackson sharks, and the caves and rock gutters in this area evidently support a resident population of these animals. These sharks appear in the shallow subtidal zone between about July and August, and are present until about February before they move on (Mike Letch pers. comm.).

Anecdotal observations from members of the Marine Care Ricketts Point group noted that the usual population of Port Jackson sharks that inhabit the caves and boulder fields in their area was conspicuously absent during January of 2009 (Mike Letch pers. comm.); it is therefore possible that many sharks from this area may have relocated temporarily to Point Cooke, a distance of approximately 23 kilometres.

Last and Stevens (2009) noted that Port Jackson sharks commenced considerable migrations to southern waters in summer and returned north during the winter. Whether this was part of a large migration of individuals from more northerly climes (and therefore an infiltration of Port Phillip Bay) is unknown. Future residency studies (which could be carried out by a combination of marine friends groups and scientific research agencies, and involve various tagging methods) would be a worthwhile endeavour to shed more light on movements of the species.

Breeding and oviposition

While Tricas *et al.* (1997) noted that groups of adults moved in and out of shallow water depending on water temperature and breeding conditions, with females and some males moving into shallower water for the purposes of mating, it appears that most of the Port Jackson shark population of Australia's southern waters commence ovulation and mating behaviour between late winter and early spring, while oviposition (egg-laying) tends to occur between late winter and spring (Tovar-Ávila *et al.* 2007). Stevens (1987) noted that females lay 10-16 eggs (meaning the species is oviparous) from late July to early October, favouring traditional sites. The eggs take 9–12 months to hatch after oviposition, and young are sustained by a large yolk sac. In New South Wales, the breeding season tends to occur also between July and November. The current aggregation, therefore, seems to be outside the envelope for these processes (even allowing for differences that may occur in the Victorian population), meaning that they can be all but ruled out as direct reasons for the aggregation.

The fact that no males were observed in this particular aggregation is consistent with the assertion by Whitley (1981) that Port Jackson sharks tend to breed on shallow reefs during winter months, with males migrating seaward during the summer months.

In the aggregation described, it is apparent that the sharks (varying in size between 40 cm and 120 cm total length) did not segregate by size (and therefore, presumably, age). These observations differ from those reported in numerous other studies, which have indicated that size-based segregation (and therefore segregation by maturity level) tends to occur (Tricas *et al.* 1997). The spatial separation of adults and juveniles in many species of elasmobranchs is well recognised, and it must be assumed that this could be due to the potential for cannibal-

ism. Based on its dental morphology and behavioural characteristics, it is highly unlikely that Port Jackson sharks would indulge in cannibalism to any significant degree, and it can be speculated that there is therefore possibly more 'leeway' in the size groupings of this species.

Last and Stevens (1994) noted that this species hatches at a size of 23 cm, with females maturing upon reaching 80–95 cm. Without having attempted to conduct measurements and collect length frequency distribution data, it is difficult to express in percentage terms how many individuals could have been expected to be sexually mature, though the suspicion of the author is that the majority of sharks were longer than 80 cm, meaning that they could have been mature or approaching maturity, while some were considerably smaller than this and were therefore presumably immature.

Feeding

Due to the fact that no feeding was observed at all during three separate observational periods, it is unlikely that feeding played a direct role in this particular aggregation. It is uncertain if sharks reverted to feeding during the night, as all observations were made during daylight hours. Edgar (2008) suggested that Port Jackson sharks are predominantly nocturnal feeders that forage for and prey on invertebrates during the night (an assertion supported by Hodgson (1987) and Whitley (1981)), which may explain why no feeding behaviour was observed throughout the entire aggregation.

It is sometimes suggested that sharks and fish are attracted towards the mouths of rivers with the promise of food that sometimes appears to follow on from high rainfall events. January 2009 was the second driest January on record in Melbourne. In this instance, because of the extremely low rainfall totals that were experienced for the local area, attraction of sharks to the area due to freshwater discharges for the period considered can be ruled out. While the prevailing northerly winds and current systems operating at the time the observations were made could have transported scents and various olfactory cues offshore and potentially drawn sharks to the area, it seems that this is a highly unlikely reason for this particular aggregation.

The Point Cooke Marine Sanctuary contains a wide variety of fauna that have been identified by various authors as being standard in the diet of Port Jackson sharks. Whitley (1981) mentioned that this shark prefers crustaceans, molluscs and echinoderms, particularly sea urchins. All of these species groups are in abundance at Point Cooke, with Sea Urchins *Heliocidaris erythrogramma* being dominant to the extent of creating numerous large urchin barrens (areas that have been stripped of macroalgae and are covered in urchins, even in daylight hours). Powter *et al.* (2010), however, implied that urchins were not as important in the diet as previously thought for this particular species. Dingerkus (1987) noted that the range of Port Jackson sharks was necessarily restricted by their diet, which featured items that were typically found relatively close to shore in temperate and tropical waters. Compagno (1987) noted that the diet of this shark consisted mainly of invertebrates, including seastars, crabs, shrimps, barnacles, marine worms, sea snails and other hard prey items, which are crushed with pavement-like molars towards the rear of the jaws; small fish are also captured and eaten. All of these prey items are in abundance at the Point Cooke Marine Sanctuary, which would therefore seemingly make an excellent foraging and feeding location for this species.

Prior documentation of mass aggregation behaviour in this species

To date there is limited information in the literature regarding very large aggregations (>100 individuals) of this species. Compagno (1984) noted that this species often has 'rest areas', which may be used by as many as 16 sharks at a time, and that the animals could range as much as 850 km from breeding areas. Powter (pers. comm, 2010) indicated that the largest aggregation size he had observed personally after eight years of research was 42 individuals, and acknowledged that aggregations in water depths greater than 30 metres that exceeded 100 individuals occasionally occurred, with some video evidence said to exist that verifies these claims. Rocky gutters have been cited as male avoidance structures by Powter and Gladstone (2008a), and sometimes contain 15 to 20 individuals in a relatively small area (such as a gutter 6 m long).

This particular aggregation occurred in an area with topography that could hardly be considered ideal for the purposes of communal male avoidance, as sharks could be relatively easily accessed by interested potential suitors.

While it is possible that some refuge from strong water movements would have been conferred by moving to the shallow subtidal region, it is noteworthy that most currents in the northern section of Port Phillip Bay are relatively minimal when compared to the conditions encountered in the open sea and coastal areas, and any longshore drift and other movement patterns would have been minimal.

Powter and Gladstone (2008a) stated that juveniles often occupy a seagrass nursery in a large coastal embayment, but the aggregation observed on this occasion was not in an area dominated by seagrass, and while some were juveniles it was clear from the total lengths observed that a considerable percentage of the sharks present were adults or were at least approaching sexual maturity.

Surely the most interesting question surrounding these observations is what actually caused the sharks to choose Point Cooke Marine Sanctuary in the numbers that they did, and how the sharks all managed to rendezvous at the same location and 'find' each other. Any discussion here is speculative, but it is likely that a combination of senses (olfactory, electrosensory and possibly even visual) could have been used to get the sharks to their shallow water destination. Hodgson (1987) noted that Port Jackson sharks were bottom dwellers with relatively small eyes, and that vision did not play as important a part as olfaction (smell) and electroreception in feeding and social behaviour. Did sharks respond to olfactory cues that were released upon an increasing number of sharks arriving in the area? It appears certain that at present, we simply do not have answers to this question, but future observations of such aggregations could well yield important clues as we learn more of the biology and behaviour of this fascinating species.

Another question concerns what caused the sharks to move away from the area, presumably *en masse*. It is interesting that when all sharks had left the area the day was fine, sunny and warm, but the following day was considerably cooler and overcast. It is possible that the animals detected an approaching low pressure system and decided to move from the shallows into deeper water, though this is only speculation.

Future work and documentation — will they return?

Even during the summer months, the beaches around Point Cooke Marine Sanctuary are not very popular with people, and are relatively poorly attended despite the idyllic location and pleasant surrounds. It is therefore entirely possible that aggregations of these animals may have been occurring regularly and gone undetected, which is made more possible by the ban on fishing that has been in force since the early 1990s (though illegal recreational fishing has been observed on a reasonably regular basis within the limits of the Point Cooke Marine Sanctuary). It is hoped that with the formation of a new community group, Marine Care Point Cooke, such aggregations will be documented in the future in greater detail than has been provided here. Equipment procured by this group in recent times includes items such as digital cameras with underwater housings, handheld GPS instrumentation and kayaks, all of which could prove invaluable in documenting future aggregations of this and other species in this particular location. That said, in the six years since the mass aggregation occurred, no other such aggregations have been observed, with only a relatively small number of sharks seen in the area. When considering the patronage of the marine sanctuary and the relatively small area that is covered during a recreational snorkel or SCUBA dive, it is not unlikely that aggregations continue to happen and simply go unnoticed. A number of authors (Whitley, 1981; Dingerkus, 1987) have noted that migration to the same favoured sites (including reefs and even crevices) year after year for the purposes of resting, mating and oviposition could be expected; O'Gower (1995) noted that this was possible on account of the species' outstanding spatial memory.

As noted by Powter and Gladstone (2008a), quantitative studies addressing habitat preferences are required to gain a full understanding of the selection of various habitats by elasmobranchs. Likewise, Powter and Gladstone

(2008b) noted that significant aspects of the reproductive biology and ecology are qualitative (as this study is), incomplete or unknown. It seems that this current record of a single mass aggregation of the Port Jackson shark reveals that their behaviour may be even more complex than previously thought.

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Ninety-eight Years Ago

Flying-fishes

By C.L. BARRETT

... From the deck of our boat I have just been watching some flying-fishes, and I thought that a note might be of some interest to members of the F.N.C. Some observers have declared that these fishes vibrate their large pectoral fins when skimming through the air—in fact, that they use them as wings. My observations to-day, and on a previous occasion when I was voyaging in the Pacific Ocean, convince me that the fins are held rigid all the time that the fish is in the air. However, I did see one to-day strike the water with its tail; it did not rise cleanly and rapidly in the first place, and the flip of the tail gave it the necessary impetus for the *flight*. Another fish I observed made an aerial journey of at least fifty yards. The flying-fishes have been of special interest to me, as we have seen no other form of animal life for some days.

From *The Victorian Naturalist* XXXIV, p. 92, October 1, 1917